CALIFORNIA
ENERGY
COMMISSION

INVENTORY OF CALIFORNIA GREENHOUSE GAS EMISSIONS AND SINKS: 1990-1999

Volume I: Executive Summary

STAFF REPORT

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Executive Summary

In September 2000, the California Legislature passed Senate Bill 1771, Sher (Chapter 1018, Statutes of 2000), requiring the California Energy Commission (Commission), in consultation with other state agencies, to update California's inventory of greenhouse gas emissions in January 2002 and every five years thereafter. The inventory update is to include all emission sources in the State that were identified in the Commission's 1998 report, *Historical and Forecasted Greenhouse Gas Emissions Inventories for California*.

This report, *Inventory of California Greenhouse Gas Emissions and Sinks: 1990-1999*, presents the Commission's estimates of emissions and carbon sinks from 1990 to 1999. As Senate Bill 1771 requires, the report includes emissions of greenhouse gases and compares California's emissions with the emissions from other states and nations. Limited information was available to allow a complete, thorough analysis and discussion of the impact of air quality and energy policies and programs on greenhouse gas emissions.

Current research has largely supported earlier scientific findings that emissions of greenhouse gases from human activities have been steadily increasing since the industrial revolution. Last year, the United Nations-sanctioned technical body, the Intergovernmental Panel on Climate Change, reported that: "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."

In response to early scientific findings related to the impact of human activities on climate, the United Nations General Assembly established the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change in 1990. At the United Nations Framework Convention on Climate Change held in 1992 in Rio de Janeiro, Brazil, over 180 nations adopted the agreement to reduce greenhouse gas emissions. The agreement was ratified by the United States the same year. At the 1997 Conference of the Parties in Kyoto, Japan, a protocol (Kyoto Protocol) was adopted to meet specific greenhouse gas emission reduction goals.

Currently 84 countries, including the United States, have signed the Kyoto Protocol. If ratified, this Protocol would mandate the United States to reduce its greenhouse gas emissions by 7 percent below the 1990 levels. Although the Kyoto Protocol has not been ratified by the United States or become the basis for climate change policy, 1990 emission baselines can be used to compare between emission trends of California and those of the United States.

This inventory was developed using new guidelines adopted by the Intergovernmental Panel on Climate Change, and is consistent with methods used to conduct the national inventory prepared by the U.S. Environmental Protection Agency.

For purposes of this report, greenhouse gases include carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Although the first three gases are also emitted from natural sources, this report primarily focuses on emissions due to human activities (anthropogenic emissions).

The California Context

California has seen a modest increase in greenhouse gas emissions in-state over the last decade. This increase is the consequence of several divergent forces within California: some lead to increases in greenhouse gas emissions, while others have led to declines in emissions over this period. These are described below.

California has a large growing population and a robust economy, which ranks fifth after the United States, Japan, Germany, and the United Kingdom. Several key California industries emit only moderate amounts of carbon dioxide. With a mild, temperate climate, California uses relatively less heating and cooling energy than other states. As a leader in implementing aggressive efficiency and environmental programs, California has been able to reduce carbon dioxide emission rates in most sectors, along with reducing energy demand and air pollution emissions. However, California leads the nation in vehicle miles traveled; as a result, CO_2 emissions from the transportation sector are increasing.

California uses fossil fuels differently than the United States as a whole (see Figures ES-1, ES-2 and ES-3). Compared to most other states, California uses less fossil energy to generate electricity. This lower reliance on fossil fuels is due to the availability of hydroelectric and nuclear power, and the continuing and growing use of renewable energy. As a fraction of its total fossil fuel use, California uses more fossil fuels (primarily gasoline) in the transportation sector.

Figure ES-1: 1999 Fossil Fuel Consumption in California and United States

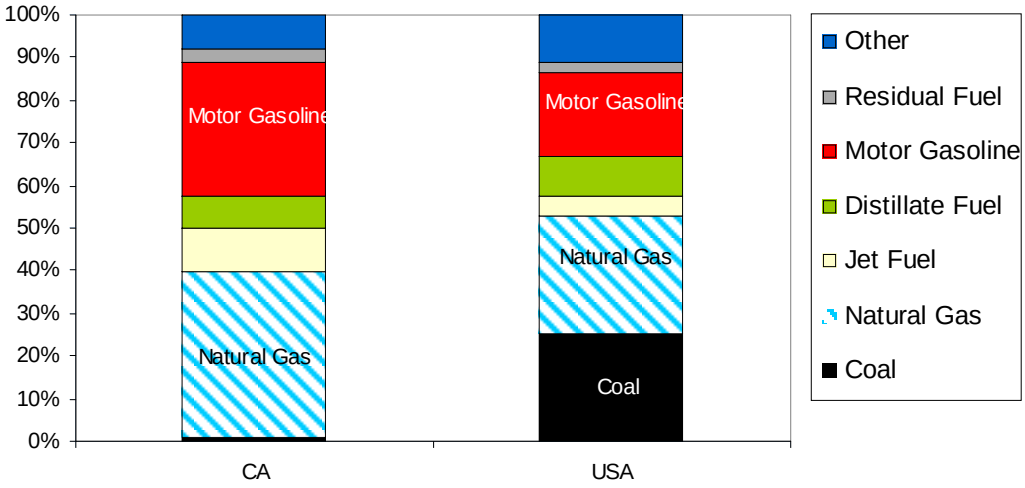
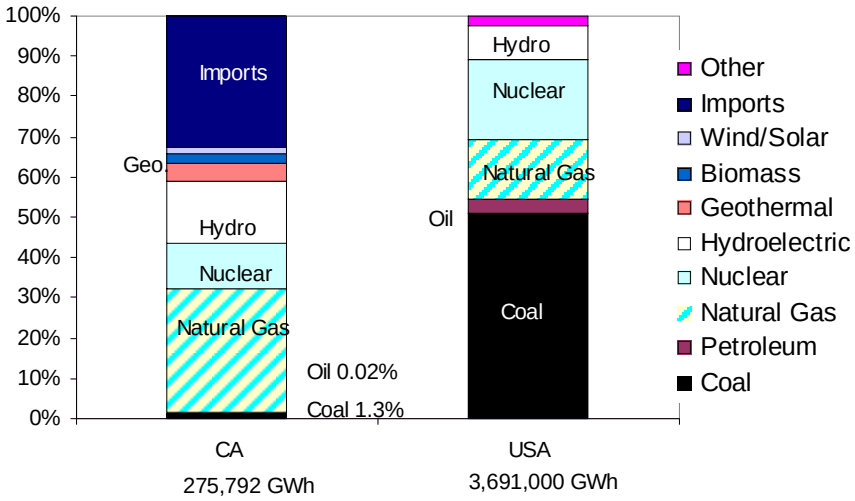
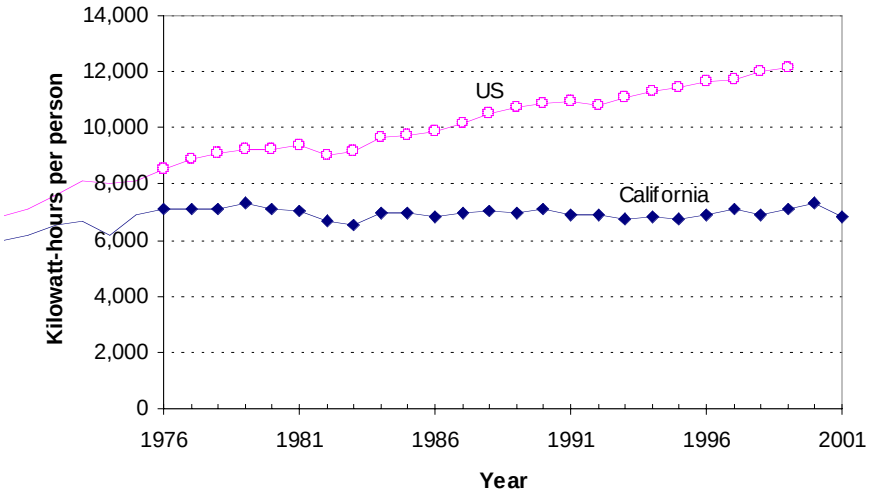


Figure ES-2: 1999 Distribution of Electricity Sources in California and the United States



As shown in Figure ES-3, California's electricity use per capita has remained flat compared to national per capita use, which increased by approximately 1.5 percent per year. On the demand side, reduced electricity consumption results from California programs such as energy efficiency standards in buildings and appliances. These programs have resulted in increased electricity conservation, which was particularly pronounced during the sharp electricity supply shortages experienced in California from 2000 to 2001. Preliminary data suggest that per capita electricity use dropped by 7 percent from 2000 levels in 2001.

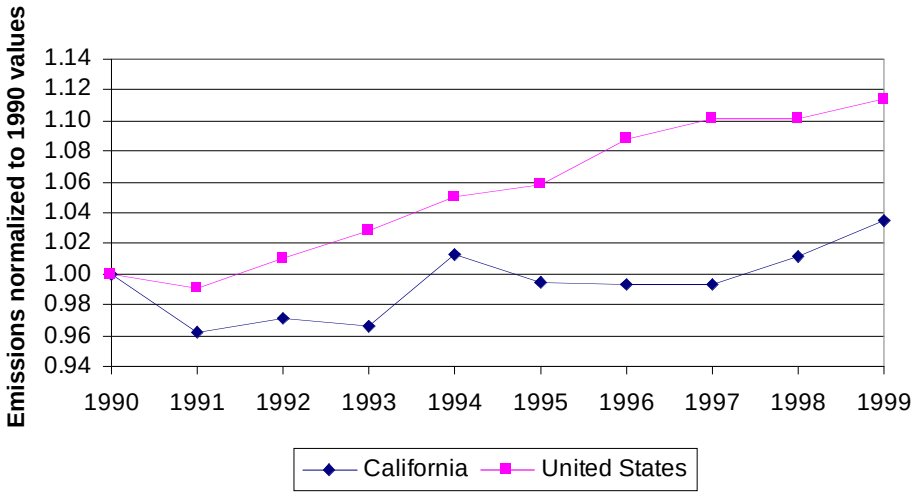
Figure ES-3: California and United States Electricity per Capita Trends Since 1976



Trends in California Emissions Levels

Figure ES-4 depicts overall trends in gross emissions in California and the United States as a whole. Gross emissions include emissions from all the in-state and United States sources normalized to 1990 levels to allow a comparison between emissions in California and the United States (i.e., gross emissions in each year are presented as a ratio of gross emissions in 1990).

Figure ES-4: 1990-1999 Relative Gross Greenhouse Gas Emissions



Economic activity and availability of hydroelectric power explains in large measure California's changing greenhouse gas emission levels. The emissions decline in California in 1991 and 1992 is primarily the result of the economic recession experienced during those years. In 1994, emissions were relatively high because: 1) a recovering economy resulted in increased industrial activity and 2) low rainfall reduced availability of hydroelectric power (see Figure ES-9), which in turn resulted in increased emissions from fossil-fueled electricity generation. Although moderated by available hydroelectric power, emissions from 1995 to 1999 increased from a strong expansion in the economy.

Changes in California's economy have contributed to the reduction in emissions per unit of gross state product (GSP). Emissions per dollar of GSP have fallen, as shown in Figure ES-5. For the period 1990 to 1999, five sectors and subsectors of the state economy accounted for 75 percent of the State's economic growth. This economic growth, however, occurred primarily during the 1995 to 1999 period. These sectors and subsectors of the California economy have lower than average energy intensities and include manufacturing of electronic equipment, computers and related equipment, wholesale trade, finance, insurance, real-estate, and services.

Figure ES-5: California Emissions per Dollar of Gross State Product

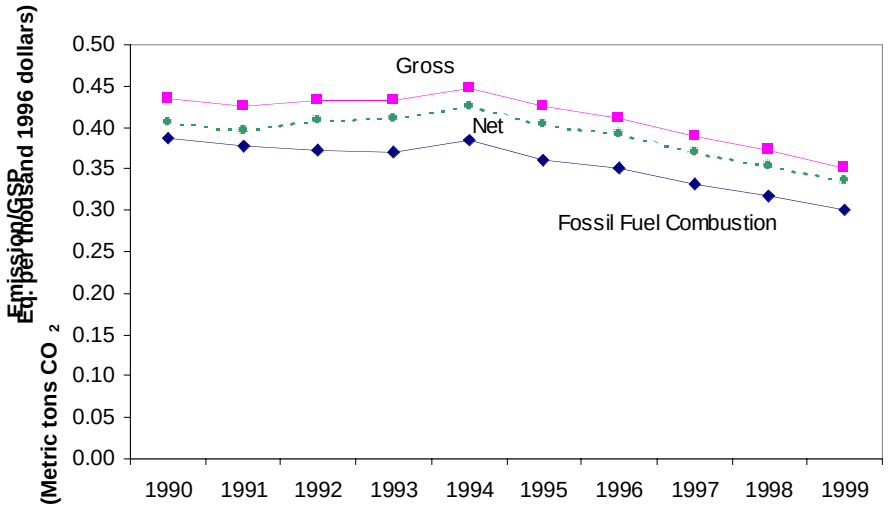
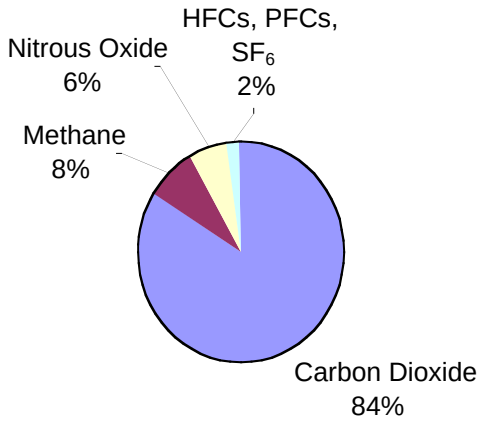


Figure ES-6 shows the distribution of emissions by greenhouse gas type. Each gas differs in its atmospheric warming properties; for example, methane has 21 times the warming potential of carbon dioxide. As a result, the relative contribution of each gas is shown on a carbon dioxide equivalent basis. At 84 percent of the total, carbon dioxide is the largest single contributor to emissions from in-state sources.

Figure ES-6: Distribution of California Greenhouse Gas Emissions by Gas in 1999



Total = 417.1 million metric tons of carbon dioxide equivalent

HFCs, PFCs, and SF_6 = Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride

Table ES-1 presents a summary of the emissions and sinks in California for 1990 and 1999. To compare the gases on a common atmospheric warming potential basis, all the emissions are represented in million metric tons of carbon dioxide equivalent ($MMTCO_2$ Eq.), using the Intergovernmental Panel on Climate Change approved conversion factors.

Table ES-1: Trend in California Greenhouse Gas Emissions and Sinks (MMTCO2 Eq.)

	1990	1999	Percent Change
Carbon Dioxide	364	363	
Fossil Fuel Combustion	358	356	
Other	6	7	
Methane	35	32	
Nitrous Oxide	25	24	
HFCs, PFCs, SF6	2	10	
Gross Emissions	**426**	**429**	**0.7%**
Soils and Forest (Sink)	-26	-19	
Net Emissions	**400**	**410**	**2.5%**
Marine Bunker Fuels	-22	-11	
Gross Emissions Minus Marine Bunker	**404**	**418**	**3.5%**
Net Emissions Minus Marine Bunker	**378**	**399**	**5.6%**

Natural processes can act to store carbon, thereby reducing the total amount of carbon dioxide in the atmosphere. These processes are called sinks, and include land-use and forestry activities which can affect the net amount of carbon dioxide emissions by absorbing and storing carbon through photosynthesis (carbon sequestration). Primarily because of a small reduction in forested land, the annual amount of carbon sequestration decreased from more than 25 million metric tons of carbon dioxide equivalent (MMTCO2 Eq.) in 1990 to less than 19 MMTCO2 Eq. in 1999.

Greenhouse gas emissions from the marine bunker fuel category affect the quantity of emissions in the California inventory. “Bunker” fuel in Table ES-1 is fuel used for international transport. Under the United Nations Framework Convention on Climate Change and the U.S. Environmental Protection Agency inventory guidelines, marine and aviation bunker fuel emissions should, if possible, be estimated and subtracted from total carbon dioxide emissions. Under the accounting guidelines, however, if the data cannot be disaggregated sufficiently to estimate these emissions, total emissions (i.e., including bunker fuel) should be reported in the inventory as part of in-state emissions.

Including bunker fuel has a significant and possibly misleading impact on overall trends presented in this inventory. A state bunker fuel sales tax imposed in 1991 for marine fuels caused major declines in the state marine bunker fuel market. Even though this tax was

repealed in 1993, the sales of marine bunker fuel have remained low, as sales of bunker fuel have been shifted out of California. As opposed to an actual decrease in marine transport or the associated emissions, the emission reductions are the result of this shift. To most accurately represent actual emissions, the results reported in this summary exclude bunker fuel from both the base year (1990) and the inventory year (1999).

Net emissions are those that are released into the atmosphere and contribute to the total greenhouse gas emissions burden on the global environment. Net emissions are estimated by subtracting the amount of carbon dioxide absorbed by sinks from the gross emissions. Gross and net emissions in California (not including marine bunker fuel) increased by 3.5 percent and 5.6 percent, respectively, from 1990 through 1999. These figures are relatively low when compared to a 12 percent and 16 percent increase for the United States overall.

Figure ES-7 presents carbon dioxide emissions by fuel type. The combustion of fossil fuels contributes about 98 percent of the total carbon dioxide emissions. Natural gas and motor gasoline consumption dominate emissions in California. The consumption of coal is minimal in the State.

Figure ES-7: Carbon Dioxide Emissions by Fossil Fuel Type for 1999 (excludes marine bunker fuel emissions)

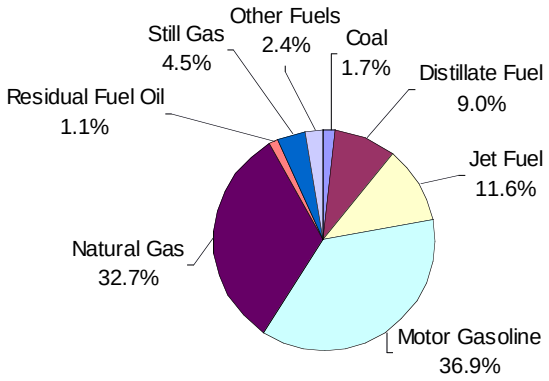
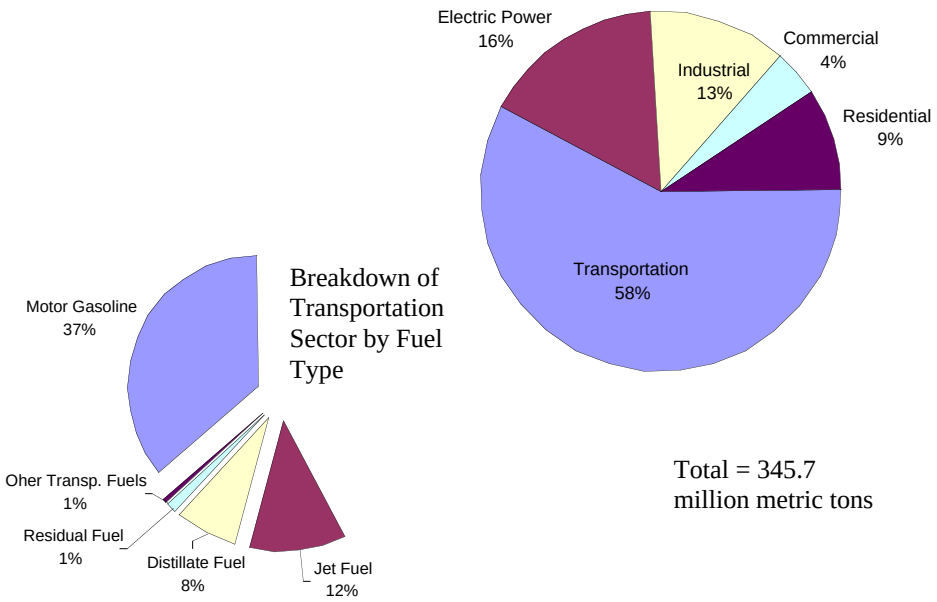


Figure ES-8 shows the contribution of carbon dioxide emissions by sector, with the transportation sector contributing more than half of the emissions. Figure ES-8 also breaks this sector down by fuel type.

Figure ES-8: Carbon Dioxide Emissions from the Combustion of Fossil Fuels by Sector for 1999 (excludes marine bunker fuel emissions)



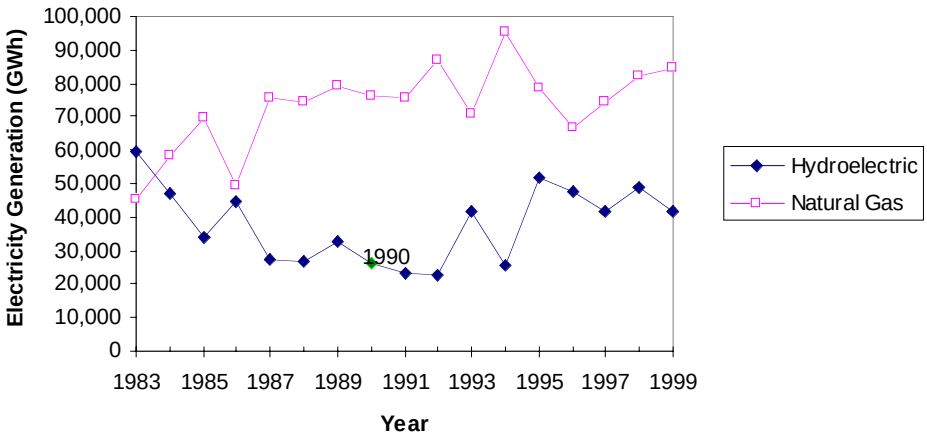
Fuel Mix in the Electric Power Sector: In-state power plants contribute about 16 percent of carbon dioxide emissions from the combustion of fossil fuels. This relatively low fraction is due in part to the mix of energy resources available to the State (at the national level, power generation contributes about one-third of the total carbon dioxide emissions from the combustion of fossil fuels). California imports a substantial amount of electricity from out-of-state power plants—a mix of hydro, nuclear, and coal—which contributes to the relatively low percentage contribution from this sector to in-state emissions.

For illustrative purposes, if carbon dioxide emissions from out-of-state power plants serving California were included, emissions would increase by about 5.5 million metric tons and the rate of increase of gross (minus marine bunker fuel) greenhouse gas emissions in the 1990 to 1999 period would have been about 4 percent. These emissions are not included for California in compliance with international and national protocols.

Emissions of carbon dioxide in the electric power sector are strongly influenced by available hydropower. The State experienced a six-year drought from 1987 to 1992, which reduced precipitation from 40 to 70 percent from normal levels during this period. As shown in Figure ES-9, because of the drought, hydroelectric generation in 1990 was reduced significantly. This reduction was accompanied by an increase in generation from fossil fuel burning power plants and higher carbon dioxide emissions. Late in the decade,

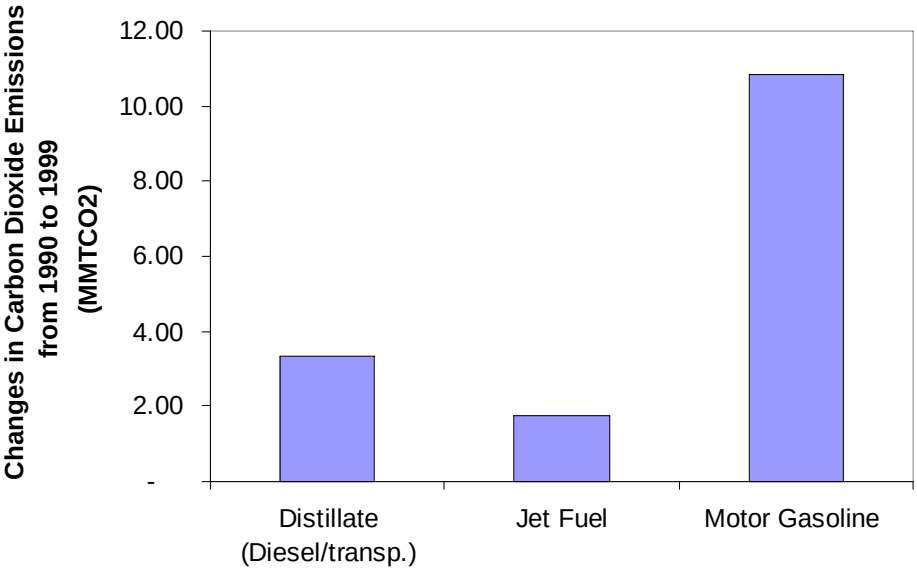
the increased hydropower helped moderate what would have been more significant increases in greenhouse gas emissions from the production of electricity in California.

Figure ES-9: Generation from In-State Hydro and Natural Gas Power Plants: 1983-1999



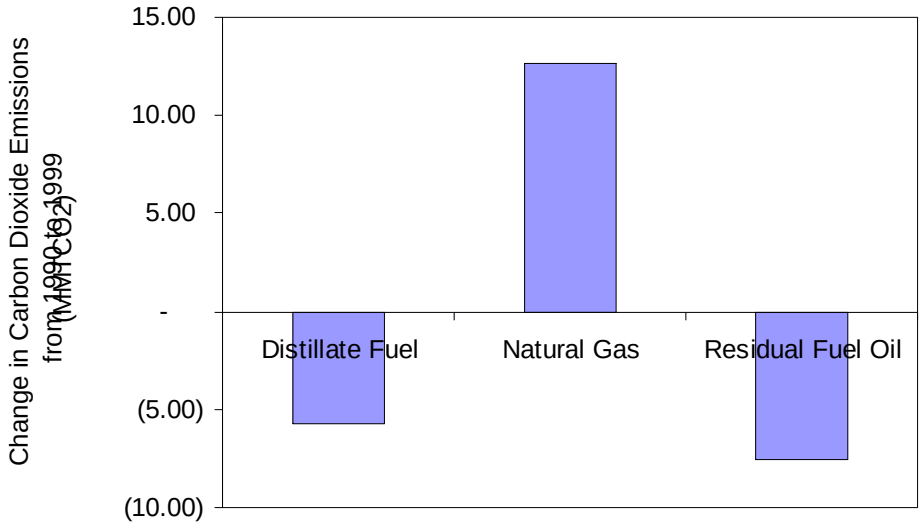
Fuel Demand in the Transportation Sector: Emissions from diesel, jet fuel, and motor gasoline in the transportation sector increased in the 1990 to 1999 period (Figure ES-10). Emissions from distillate, jet fuel (for commercial and military transport), and motor gasoline consumption increased by about 14.3, 4.5, and 9.4 percent, respectively.

Figure ES-10: Changes in Carbon Dioxide Emissions from Diesel, Jet Fuel, and Motor Gasoline Consumption in the Transportation Sector



Fuel Switching in the Commercial, Industrial, Electric Power and Transportation Sectors: During the 1990 to 1999 period, the switch from distillate and residual fuel oils to natural gas resulted in a decrease in emissions because natural gas produces less carbon dioxide than the other fossil fuels. The reductions of fuel oil consumption occurred for distillate in commercial and industrial boilers and for residual fuel oil in power plants and domestic marine transport. The switch from residual fuel oil to natural gas in power plants started in the mid-1970s, but some residual fuel oil was still burned in power plants in 1990. These fuel oil reductions were accompanied by substantial increases in the amount of natural gas burned in California as shown in Figure ES-11.

Figure ES-11: Changes in Carbon Dioxide Emissions from Distillate and Residual Fuel Oils, and Natural Gas: 1990-1999 (excluding marine bunker fuels)



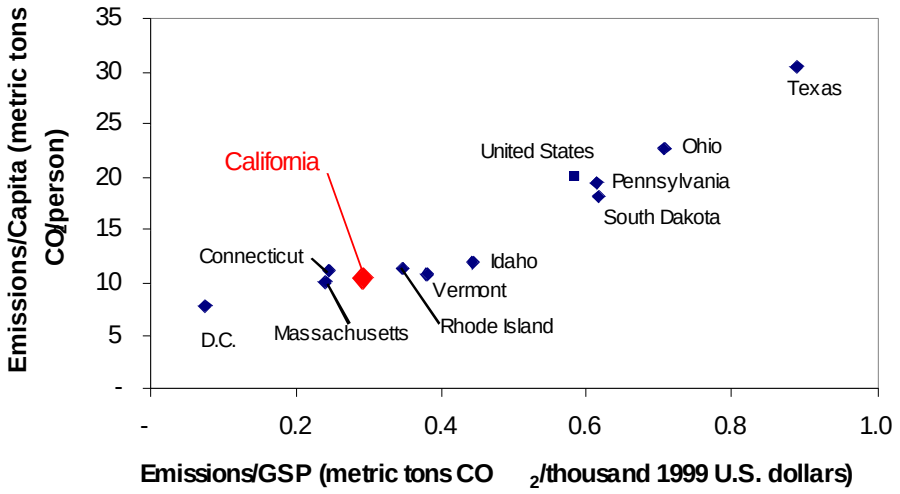
Air quality regulations in the mid-1990s required a more stringent level of control of nitrogen oxides, and because of cost considerations, many facilities shifted from fuel oils to natural gas in commercial and industrial boilers. In addition, California refineries processed less crude oil (about 9 percent) during the 1990 to 1999 period, which resulted in a decrease in the production and consumption of still gas and other gases used during the processing of crude oil. This change in crude oil processing and the modernization of the state refineries may have reduced the availability of residual fuel oil, which is a low value fuel in California.

Comparison of California Emissions with Selected States and Countries

California is characterized by a moderate climate, industries that emit relatively moderate levels of carbon dioxide, and active energy and air quality programs capable of indirectly reducing greenhouse gas emissions. As shown in Figure ES-12, California's emissions per capita and emissions per dollar of state product are low compared with other states.

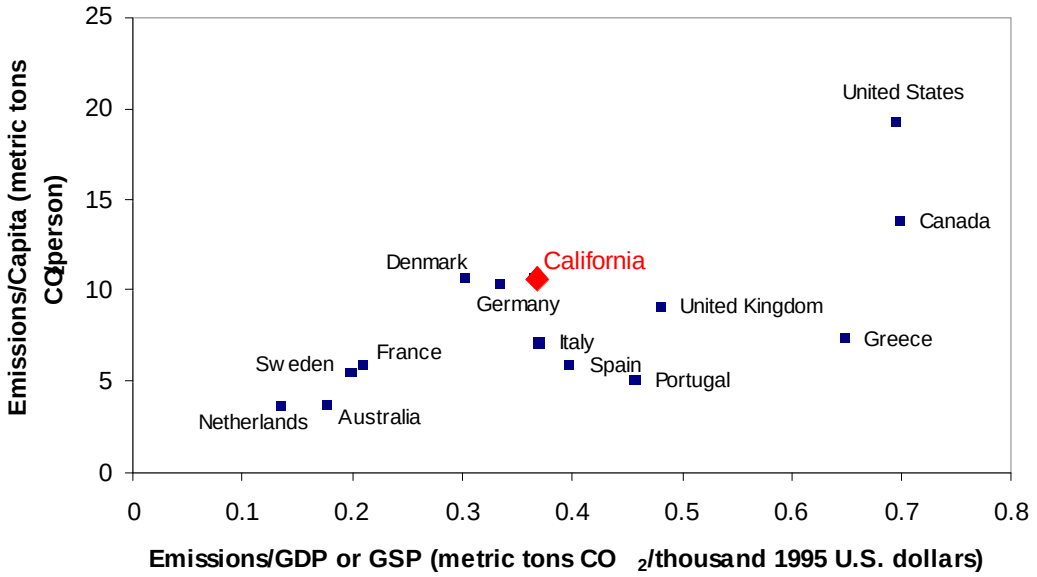
The rate of emissions growth in the State is relatively modest compared to increases elsewhere in the United States. These comparatively modest increases are the result of: fuel switching to natural gas; relatively low hydropower production in 1990 that was compensated for by burning fossil fuels in power plants; the continuing effect of energy efficiency policies and standards; and, an increase of electricity imports. Without these factors, gross emissions in 1999 would have been about 8 percent higher in 1999 than in 1990. Even though California's rate of emission growth has been modest, its total carbon dioxide emissions are very high, second only to Texas among the states.

Figure ES-12: 1999 Carbon Intensity from the Combustion of Fossil Fuels for California and Selected States



In the international arena, California emissions per dollar of gross state product are much lower than U.S. emissions from fossil fuel combustion per dollar of gross domestic product, but as shown in Figure ES-13, comparable with several western European countries.

Figure ES-13: Carbon Intensities for California and Selected Countries - 1995



Future Emission Levels

The Commission staff forecasts significant increases in natural gas, motor gasoline, diesel fuel, and jet fuel consumption. For example, fuel use in California's transportation sector, representing nearly 60 percent of the carbon dioxide emissions, is forecast to increase from 1990 levels by 60 percent through 2020.

The data needed to estimate emissions in 2020 for sectors other than transportation are currently unavailable. It is possible, however, to forecast gross emissions for all sectors through the year 2010. Using existing forecasts and assuming consumption of all other fuels remains constant, carbon dioxide emissions from the combustion of fossil fuels in California will increase by about 20 percent from 1990 levels by 2010. Since consumption of other fuels is also likely to increase, this level represents the minimum expected increase in greenhouse gas emissions by the year 2010.

Refinement of Inventory Methods

The emission estimates presented in this inventory represent the best data and methods available, given time and resource constraints. The development of the current inventory has raised issues concerning data quality. Data quality concerns also arise from the current methodologies and protocols designed to disaggregate the data. In particular, there are data quality concerns regarding protocols used to develop emissions data for international marine and aviation fuels.

Although this report does not address the significant uncertainties associated with estimating greenhouse gas emissions, this subject will be addressed in a forthcoming report developed through the Commission's Public Interest Energy Research (PIER) Program. In future greenhouse gas inventories, the Commission plans to refine the state greenhouse gas emission estimates further by:

1. Incorporating improved data and methods planned and under development;
2. Updating emissions estimates to the most recent year;
3. Presenting a discussion of the uncertainty in emissions estimates from key sources;
4. Improving emissions estimates (e.g., emissions associated with international bunker fuel) and estimating emissions for sources not currently in the inventory.

Summary

Overall, California has done well in comparison to national emissions trends. Over the ten-year period from 1990 to 1999, California's gross state product has increased by 28 percent and its population has grown by 10 percent, while its total greenhouse gas emissions have only increased 3.5 percent. By comparison, the U.S. has experienced a 12 percent increase in greenhouse gas emissions over the same ten-year period.

California has been able to reduce its per capita carbon dioxide emission rate by 8.6 percent, from 13.2 tons of carbon dioxide equivalent per person in 1990 down to 12.4 tons of carbon dioxide equivalent per person in 1999. In terms of per dollar of gross state product, the state lowered its "greenhouse gas intensity" by 19 percent, from 0.96 lbs. of carbon dioxide equivalent per dollar of gross state product in 1990 down to 0.77 lbs. of carbon dioxide equivalent per dollar of gross state product in 1999.

This analysis concludes that carbon dioxide emissions from the combustion of fossil fuels remained more or less constant for combined electricity generation and industrial use, primarily due to fuel switching and abundant non-fossil fuel choices (renewable, hydro, nuclear) for electricity generation. These modest increases throughout the 1990s are also due to aggressive state control of criteria air pollutants, which can lead to a reduction of carbon dioxide emissions.

Carbon dioxide emissions have grown substantially in the transportation sector. This growth is especially true for gasoline-based emissions, which have increased by about 9.4 percent over the decade.